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Calf Respiratory Disease II - the influence of certain environmental factors.

by J.R. Starr.

Agricultural Memorandum No 957.

Introduction

Respiratory disease is a major problem in calf rearing in Great Britain especially under intensive husbandry systems (Roe 1982). The new approach to CRD research, notes Pritchard (1980), must be one of recognising the multifactorial aetiology of the disease. The 'risk-factors' must be identified and investigated; this involves a multi-disciplinary approach to assess the impact of management, housing, nutrition, climate, microbiological environment etc (A discussion on the modelling of susceptibility to CRD and of assessing the risk due to the various environmental influences is presented in Ag.Mem 956).

This Memorandum presents an account of a multi-disciplinary study mounted to complement investigations by the Pest Infestation Control Unit at Coley Park, Mrs Hockland of that Unit having found circumstantial association between outbreaks of calf pneumonia and the build-up of forage mites in food and bedding in several calf houses. (Mites can cause a hypersensitive reaction in the calf out of all proportion to the magnitude of the challenge from the bacterial population within the respiratory tract i.e. a distortion of the immune response').

FH2B

Materials and Methods

In a pre-season planning meeting in summer 1981 work protocols were established by each unit (Appendix I). Of the CRD disorders reported to the Veterinary Investigation Officers, two incidences per month for 5 months were to be subjectively selected for investigation by the inter-disciplinary team.

To avoid an embarrassing number of personnel descending on the farmer visits were staggered. In retrospect this meant that environmental conditions were not being assessed contemporaneously (and certainly not at the time of disease onset. Indeed workloads dictated that, on some occasions calves had been moved to a different building by the time of the visit).

'Non-disease' farms were selected as 'controls' and visited frequently by some units. At each farm the various disciplines carried out the following surveys.

Pests Unit:	mite counts from trough food and bedding (mite extracts subsequently tested for allergic reaction in calves by I.R.A.D. Compton).
Microbiology:	Volumetric sampling of micro-organisms (bacterial, moulds and actinomycetes); dust counts in the air as well as samples during agitation of bedding.
Nutrition Chemistry:	Constitution and quality of diet through analysis of hay/silage, straw and feed concentrates.
Farm Buildings:	assessment of buildings (eg ventilation, air flow) and state of bedding.

Meteorological Office: in collaboration with Farm Buildings; measurements of internal environmental parameters including air change rates. Estimates of site exposure to frost risk and wind.

Veterinary Investigation: disease severity estimates from blood samples, nasal swabs, and post mortems. History of disease calves eg number, ages, origin , breed, vaccines. Tests for microbes that have been associated with CRD - IBR, BVD, PI_3, RSV, Mycoplasma bovis and Haemophilus somnus.

Discussion

The summaries of the analyses of various units will now be presented:

Pests Unit: The data showed that mites (of the group Astigmata) which have been implicated in human allergy problems were found on all farms. Although numbers were not as high as expected, few conclusions could be drawn since information on the significance of density is scarce.

There was little difference in numbers of mites found on the 'control' and the 'disease' farms, although straw bales, if present generally contained high mite populations on 'disease farms'.

Relatively few mites were found in food mixes but the calves were generally surrounded by bedding, ricks and straw bale wind-breaks which contained mites. Their significance remains to be proven.

Microbiology: The air of animal houses contains micro-organisms from many sources

such as the animals themselves, their excreta, bedding and feed. Certainly the involvement of spores in respiratory allergies in humans is well known and while little is known of the involvement of fungi in calf allergies, it seems likely calves could be prey to micro-organisms known to be allergic in man.

The results obtained demonstrated the variability of air quality in different types of calf housing and in one case (Farm A) the variability on a single farm over a period of time.

Farm C, which gave the lowest counts, housed calves in an intensive unit with controlled ventilation and on sawdust and sand rather than straw. In other housing bedding was straw and ventilation natural. High counts on Farm E were closely related to the condition of the bedding since a considerable increase in counts occurred when the straw was agitated. Particle counts on the two problem farms checked by this unit were considerably higher than counts from the three regularly checked controls.

Large numbers of potentially allergic fungi may be present in the environment of apparently symptomless calves.

Farm Buildings: Inspection of the buildings and their siting allowed a qualitative assessment of the adequacy of ventilation and the sheltering of stock from draughts. These assessments were put on a more quantitative basis by studies in collaboration with the Meteorological Unit of air-change rates (using an SF_6 gas analyser), air trajectories (by flow visualisation with a smoke puffer) and measurements of internal and external temperatures and relative humidities. Because visits were made generally at a different time from those of other units for logistical and other reasons these measurements could not in general be related to the other microbiological etc, factors.

Our site-visit summaries are presented in Appendix II.

Veterinary studies: A nicety of the already complex environment/management/disease risk interactions is that CRD is associated with a number of pathogens ie PI_3 (Parainfluenza), RSV (respiratory syncital virus), Enterovirus, Parvovirus, Adenovirus BVD (bovine viral diarrhoea).

Each is thought to have a range of temperatures and humidities under which it will thrive and outside of which it is less viable, indeed may die (C Jones et al 1982).

To make a quantitative assessment of the overall efficacy of the enterprises studied the other co-operating units were encouraged to 'have a go' at filling in the Rational Decision Box (Ag. Memo 956). In the event .....(fig 1). Nevertheless this Memorandum is presented without such entries but as a suggested methodology for future CRD studies.

Summary

The 1981/82 programme of CRD investigations emphasised the need for a quantification of the various environmental factors both in terms of relative importance and on an absolute scale.

The latter will be difficult to achieve if numerous farms each with different management systems are studied (Ag. Mem 956). Thus it is suggested that in future CRD studies a few farms are investigated over a longer period - such farms being selected for similar management policies (eg as regard re-stocking with homebred or bought-in calves). "Climate" studies should be extended to obtain an integrated measure of environmental temperature as given for example, by a Wet Bulb Globe Thermometer (Clark & Cena 1981). Investigations of internal climate, and ventilation

rates etc under different meteorological conditions but certainly under the extremes of windy and wet and calm and dry, to establish the range of conditions encountered by the calves.

If possible past veterinary records should be obtained and an attempt made to match factors such as sharp afternoon/night temperature drops, and low wind speeds with disease levels and timing, due allowance being made for virus incubation periods.

Acknowledgements:

To Mr C P Roe and Mr R D'Costa who were loaned out from Met O8a to aid with the operation of the SF_6 device. To my colleagues in our cooperating disciplines, particularly Mr Allott of the Farm Buildings Group.

All comments and suggests to the author.

Meteorological Office
MAFF Reading
January 1983

cb

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Appendix I

Proposed calf health and environment study, winter 1981/2. Suggested protocol for Meteorological and Farm Buildings visits.

1. Assumed that initial contact will probably be by local veterinary practitioner to ADAS - (David Kirby and then on the Christine Wayman).

   We would request permission to make 2 or 3 visits during the winter to record environment in different "weathers".

2. Initial visit should be co-ordinated with several disciplines if possible. Ours should be while calves are in the building - not always so last winter.

3. We want the date(s) of serious outbreaks this season, (and for previous seaons when available) in order to examine weather records for possible connections.

4. On site we will record:

   a. Building measurements, construction details and nearby features influencing microclimate.

   b. Climatic measurements:

      Relative Humidity)
      Air Temperature) inside and outside house at floor level,
      Air speed) calf standing height and above or appropriate

      Wet bulb globe temperature (Comfort Index)

      Air change rate and hence air renewal rate.

PROJECT No. BP05:

Work Schedule for Infestation Control

Procedure for Disease and Non-Disease Farms

1. One 500g sample each of food in trough, hay being eaten, and straw bedding to be taken for mite extraction. If food or hay not available in calf house, then to be sampled from store.

2. Samples to be stored in deep freeze prior to examination.

3. Samples to be put through mite extraction procedure. Mite counts made and mite species mounted and identified.

4. Samples as 1. above to be taken according to Nutrition Chemist's instructions for nutritional analysis.

5. Samples to be received from Microbiologists' dust extraction, and subject to steps 2 and 3.

6. Full disease precautions to be taken on every visit.

7. No assistance will be required from farm staff for any work.

8. Results circulated to all participants.

9. Results of all work done in connection with this project to be written up in conjunction with the V.I.O.

S. Hockland
x 326

Christine Wayman
Senior Adviser (Biostatistics)

Mites/Pneumonia investigation

Work schedule for Nutrition/Analytical Chemistry

Analysis:-

Compounds	DM, CP, CF, Oil, Ash
Hay/Silage	DM, CP, MADF, Ash (pH, NH_3N on silage)

Nutrition Chemist to evaluate ration for adequacy.

CALF RESPIRATORY DISEASE SURVEY
VETERINARY PROTOCOL

(1) SAMPLES

a) Blood samples - Paired blood samples with at least a 14 day interval from at least 6 calves. 20 ml. of clotted blood collected from each calf. Serum to be tested for IBR, BVD, PI_3, RSV, Mycoplasma bovis and Haemophilus somnus antibodies. Spare serum will be kept frozen for possible mite serology and fungal gel tests. EDTA samples may be collected for eosinophil %.

b) Nasal swabs from the same calves will be taken for virus and mycoplasma isolation. Bacteriology (BA Mac Choc/CO_2) will be carried out on those calves that have not had recent antibiotic treatment.

c) Carcases or lungs if any calves die - protocol has been agreed with I.R.A.D.

(2) HISTORY

i) Number of calves in building

ii) Ages of calves in building

iii) How long have calves been in building

iv) Origin of calves
- homebred
- purchased local farms
- market/dealer

v) Breed(s) of calves

vi) Vaccines - IBR or Pneumovac

vii) Approx date of onset of outbreak

viii) Number of deaths prior to 1st visit

ix) Number of deaths up to 2nd visit

x) Some assessment of disease severity

(3) ROUGH DESCRIPTION OF HOUSE

Surface area of pens
Volume of building
Type and wetness of bedding
Type of building - new/old
modified/purpose built/general purpose
air inlets and outlets - number and type
brick, breezeblock, asbestos, yorkshire boarding
any fans

DRAFT

DESIGN OF INVESTIGATION

1. Preliminary testing of mite extracts on calves by Mr Thomas, IRAD, Compton.
2. Visits to a maximum of 2 farms per month where respiratory disorders in calves have been diagnosed and to 2 control farms.
3. Counts of moulds, actinomycetes and bacteria in the air of the calve's environment using an Andersen air sampler.
4. Air sampling for gravimetric dust estimation (if an appropriate sampler can be obtained).
5. Monitoring of temperature and relative humidity of calve's (calves') environment.
6. Collecting (on) of samples of hay, straw and feed from disease and control farms
7. Laboratory analyses of samples for mites and for nutritional value. Additional testing for moulds may be carried out if appropriate.
8. With cooperation of farmers :-
   i) tests on calves by IRAD or VIO
   ii) autopsies on dead animals
9. Monthly monitoring of a farm with a history of virus pneumonia.

Characteristic or Criterion	Volume / calf		Air change / hour		Air speed at calf height		state of bedding		Climate		Ventilation		Water population		Microbiological & particle environment				Overall Acceptance
weight	3		2		3		2		2										
FARM																			
A	5	15	4	8	4	12	4	8	5	10									
B	5	15	3	6	4	12	4	8	4	8									
C	4	12	5	10	4½	13½	4	8	3½	7									
1	5	15	4	8	3	9	4	8	3	6									
2	5	15	3	6	1	3	4	8	3½	7									
3	5	15	2½	5	2½	7½	4	8	4½	9									
4	4	12	4	8	3	9	4	8	4½	9									
5																			
6	5	15	2½	5	4	12	4	8	3	6									
7	4	12	2	4	4	12	3½	8	4½	9									
8	5	15	3	6	1	3	4	8	4½	9									

Elements of the Rational Decision Box are filled in as follows:

weight	w	
Farm X	effectiveness e	acceptance w x e

weight : How important do you rate this particular characteristic or criterion?
effectiveness : How effective was it in this case?
(Scale : 1 : low importance, not at all effective → 5 : very important, very effective)
Acceptance level of the characteristic is weight x effectiveness. Sum for overall acceptance

SW

Appendix II

Mites and Cattle. Winter 1981-82. Site Visit

Farm A. 'Control'. Bridgets EHF.

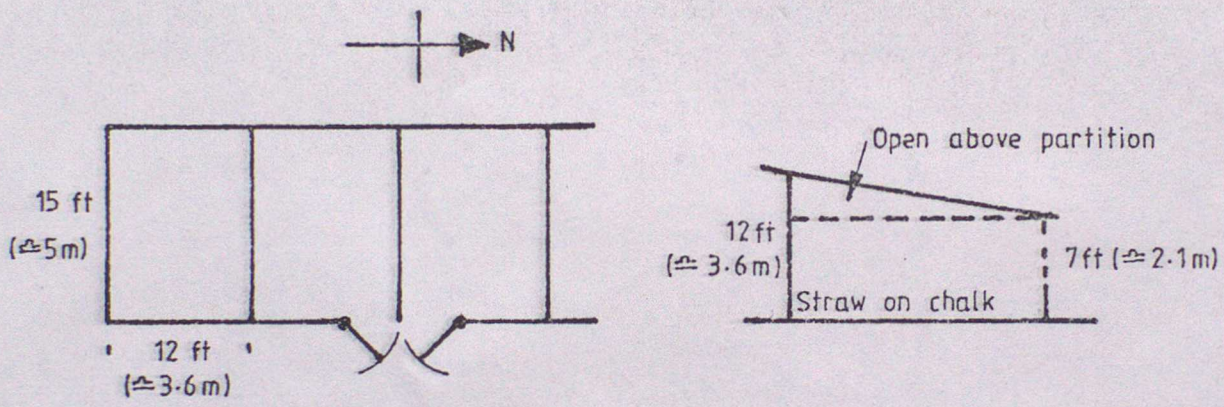
Visited on 2 March, 1982. J. Starr, D. Allott and helpers.

Siting. Although an exposed site at 90-100 m the location of the calf house in relation to a chalk bank and other buildings renders it reasonably sheltered from all directions.

Weather at visit: Blustery wind SW gusting to 7 m/s, rain starting; the approach of a wet evening!

Buildings. Simple, old monopitch range of stable type loose boxes. Half heck doors at front, boards missing at top of back wall.

Sketch:



Measurements taken.

Outside windspeed 7 m/s.
Inside windspeed 1½-2½ m/s. 0-0.3 at calf level.
Temperatures similar inside and out.
R.H. Impractical to measure during rain.
Air changes. 32/hr.

Assessment. On windy day - good air changes, no draughts for calves.

Mites and cattle. Winter 1981-82. Site Visit

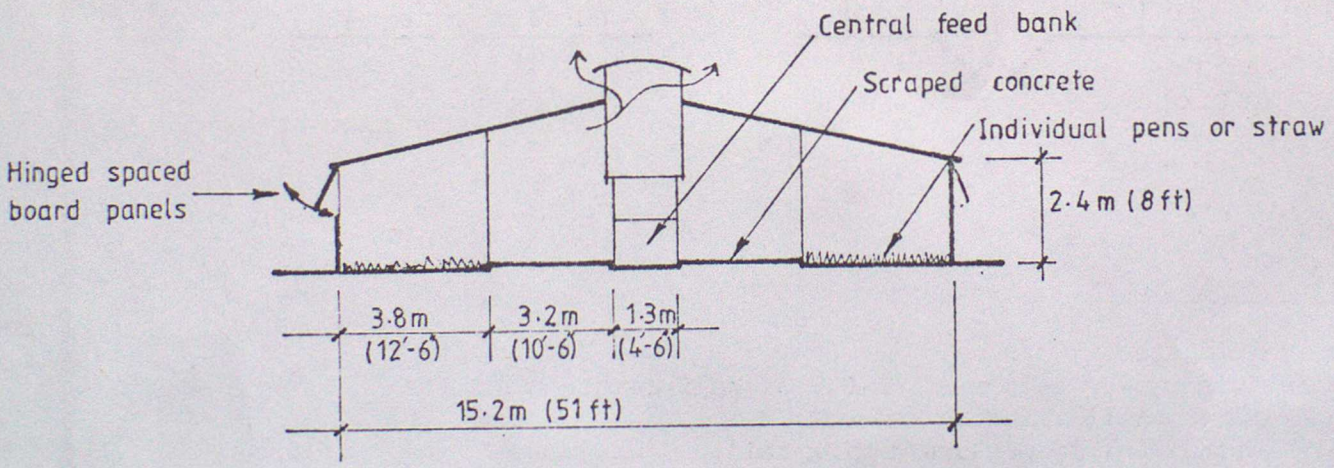
Farm B. 'Control'. Home Farm, Charlton, Wantage. Mrs D. Castle.

Visited on 12 November, 1981. J. Starr, D. Allott and helpers.

Siting. The building lies in a gentle hollow with other farm buildings to the West and North West. It is well exposed without being over exposed.

Weather atvisit. Overcast, breezy South-Westerley gusting to 5 m/s.

Buildings. Home built gabled pole barn, significantly adapted to improve ventilation and drainage after receipt of much varied advice following some severe respiratory disease crises! Straw bale walls now replaced by recycled plastic boards to reduce scope for mould and mite accumulation. Airy building with much adjustment of spaceboarded inlets possible. Well ventilated roof with spaced sheeting and large capped ridge outlet.



Measurements taken.

Outside: windspeed up to 5 m/s.
Inside: drift at north door 1.05 m/s.
At ridge (5 m high) 4 m/s.
at 2½ m 0.8 m/s
at 2 m 0.5 m/s
at straw level 0.3 m/s
Temperatures Outside 10° inside 11°C (average)
In straw 14°C
In straw just vacated by calf 27°c
Rel. Humidity 80% outside 82% inside (average)
Air Changes. Gas decay records. Mean of readings 1 m above ground in centre of house gave 26 air changes/hour.

Assessment. On breezy day - good airchanges, no draughts for calves.

Mites and Cattle. Winter 1981-82 — Site visit

Farm C. — 'Control' NIRD, Arborfield, Reading, Berks.

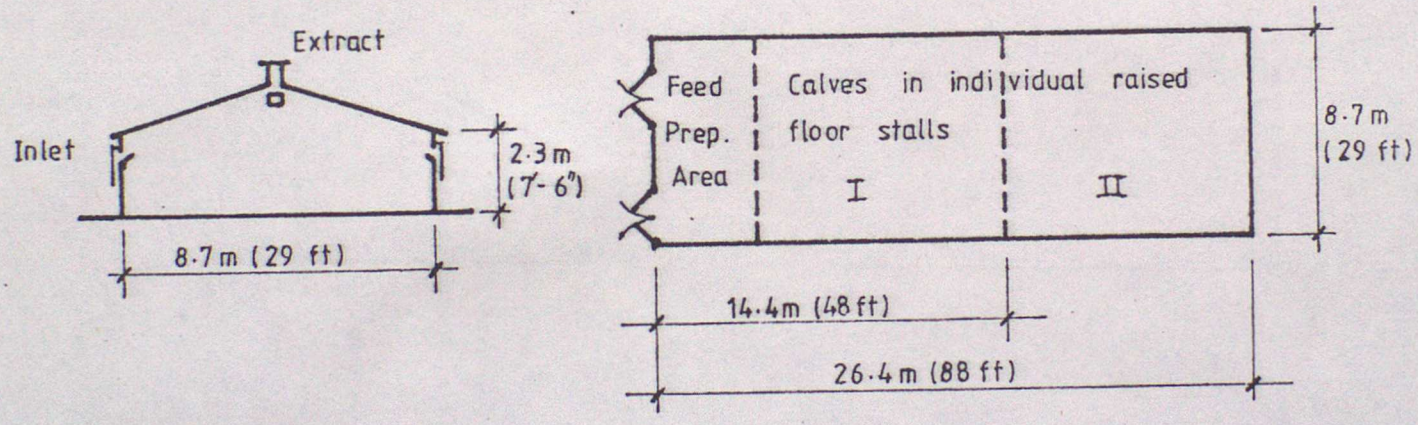
Visited on - — 14 July, 1982. J. Starr, D. Allott and S. Mika.

Siting. — Building block at W end of large field. Ground slopes more steeply from buildings to River Loddon about 300 m away. Exposed to winds from North through East, with slightly more shelter from South and South East due to trees of up to 15 m height at distance of about 200 m.
Due to many trees by Loddon impeding cold air drainage, thesite is a likely frost hollow.

Weather at visit. — Overcast, still.

Buildings. — Proprietary package building, like poultry house. Wall inlet and fan extracted duct on ridge.

I = 4 banks 13 pens
II = 3 banks 12 pens



Measurements taken. — Outside wind temperatures and R.H were not relevant as building unoccupied at visit.

Ventilation air changes. Gas decay records made with fans on, and doors closed in each compartment.
Volume I 375 m^3, 14.3 air changes/hour.
Volume II 313 m^3, 13.8 air changes/hour.

Assessment. — (On a still day, with no stock) but air change rate and airflow, generally above calf height, were satisfactory.

Mites and Cattle. Winter 81-82 Site visit

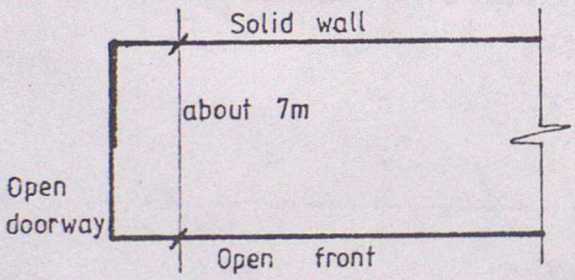
Farm 1 Haileywood Farm, Shiplake. Mr Doble

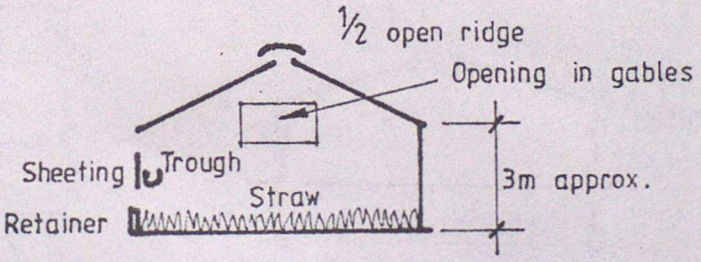
Visited on 3 November, 1981
J Starr, D. Allott, D. Hughes and helpers

Siting Farm buildings are in a well defined 'frost hollow' prone to mists etc. Higher surrounding ground tends to funnel winds, especially S. Westerlies which become more Westerly.

Weather on visit Overcast, cool. Fresh South Westerly gusting to 8 m/s. Within the building grouping this reduced to 2 m/s.

Buildings Cattle and calves were housed in a variety of buildings. Older cattle were now occupying a yarded barn in which a severe outbreak of pneuomonia had occurred when calves were in it. The calves were now housed in a series of boxes (old stables?) and a long shed with one side mostly open.





The loose boxes were brick and weather boarding with tiled roof and part height partitions between; abtut 4 m x 4 m on plan with 1 m wide half-heck door.

Measurements taken Outside windspeed. Open ground 8 m/s. Amongst buildings 2 m/s. Inside windspeed. Loose housing: gusts to 2 m/s at front above feeder to 1.5 m/s under feeder. Up to 0.5 m/s at straw level in back of house. Draughty throughout. Boxes: gusts to 1 m/s by door. 0.4 m/s over partitions 0.2 in calf level air and straw by door. 0.05 m/s at back. Temperatures. Outside 13°c Inside 14-14.5°c average. Relative Humidity. Average 80% inside and outside. Air changes. Gas decay records gave averages of 18 changes per hour in both boxes and strawed yard.

Assessment Building complex provides useful windspeed - reducing shelter. Boxes provide good conditions, loose housing is mostly draughty at calf level.

Mites and Cattle. Winter 1981-82 Site visit

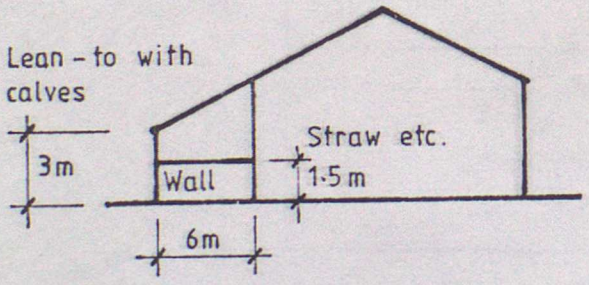
Farm 2 Littlefield Manor Farm, Worplesdon. Mr Tangye

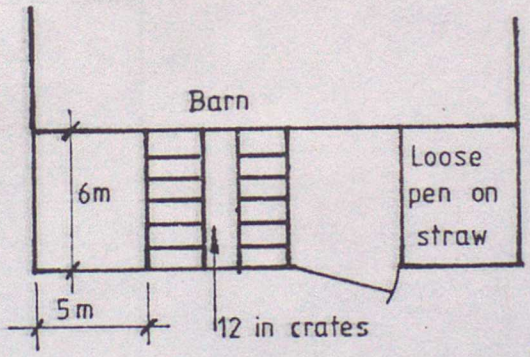
Visited on 28 October, 1981
J. Starr, D. Allott and helpers

Siting The farm is in a shallow hollow near the 46 m contour. Cold air drainage to East should prevent it being a 'forst hollow'. Exposed to Easterly winds, less so to Westerlies.

Weather on visit Overcast cold. Wind SW and increasing with rain expected in a few hours. Gusty, but only of about 2 m/s.

Buildings Converted cow cubicles and the lean-to area of a barn were used for calves. On our visit only the barn accommodation was in use with some calves in individual pens and others in groups.
Netlon windbreak was being fixed to the barn standions while we were there. This is to reduce draughts around the calves.





Measurements taken
Outside windspeed 1.5 m/s, more in gusts. Inside 0.5 m/s by crates, 1 m/s at straw level in pen. This is 4 times recommended maximum, and is draughty.
Temperatures. Outside - 11.4°c. Inside - 11.6°c (average)
Relative Humidity. Outside - 76% - Inside 75% (average)
Air changes. Recorded beyond the reliable range of the instrument.
36, 46 and 64 air changes/hour. 12/hour would be sufficient.

Assessment The pens were overventilated and draughty with no strong wind. Temperatures and RH barely modified by building. Further shelter provision is recommended to farmer.

Mites and Cattle. Winter 1981-82 Site visit

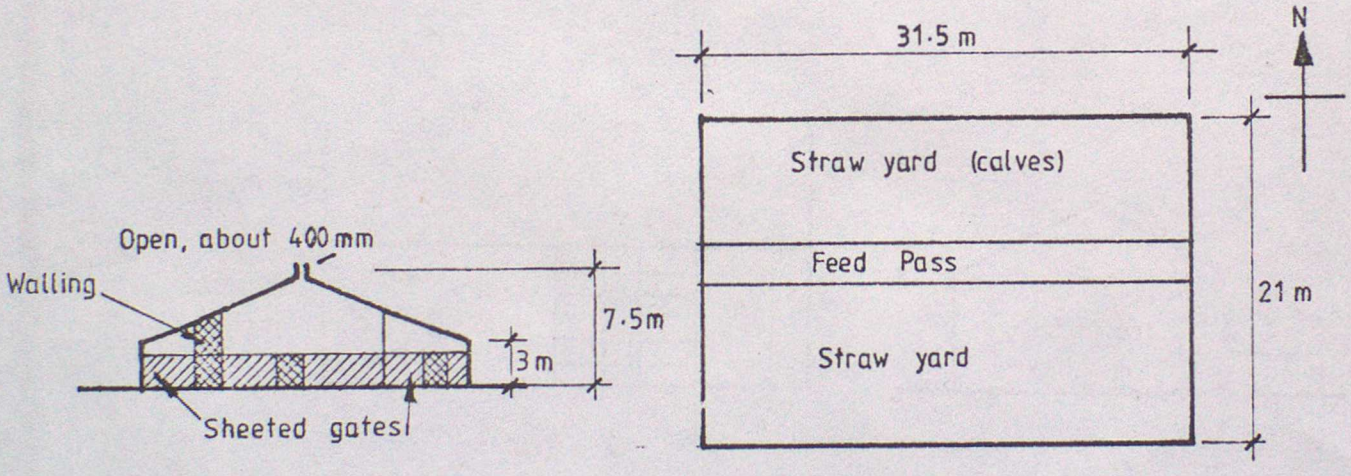
Farm 3 Whitehouse Farm, Upper Lambourn. Mr Barratt (Fognam Farmsite)

Visited on 5th January, 1982.
J. Starr and D. Allott

Siting Near the bottom of a valley running E.W with high ground close-by to S and W. These offer "channelling" of winds and, in "radiation" conditions, the build-up of cold air from "donor" sites to South and West. Although cold air drainage to the East can occur, the Manager reported the site to be frequently in mist.

Weather on visit At Mid-day the windspeed was practically zero. Overcast, with temperature about 11°c.

Buildings Calves had been housed in a straw yard forming part of a large 7 bay barn with lean-tos. There was no stock present during ourvisit. The straw yard was backed by a block wall with spaced boarding above. The south side was completely open and the two gables were substantially unclad.



Measurements taken No measurable wind. With no stock in the building, we only recorded temperatures and RH.
Inside - 10.5°c @ 88% RH; Outside - 10.2°c @ 90% RH.

Assessment Although in a locally sheltered location between higher ground, the site is exposed to channelled winds from East or West. It is probably very draughty during windy weather. The Manager asked advice and was strongly recommended to close up most of the large gable openings and to consider planting shelter vegetation to South and East.

Mites and cattle. Winter 1981-82 Site visit

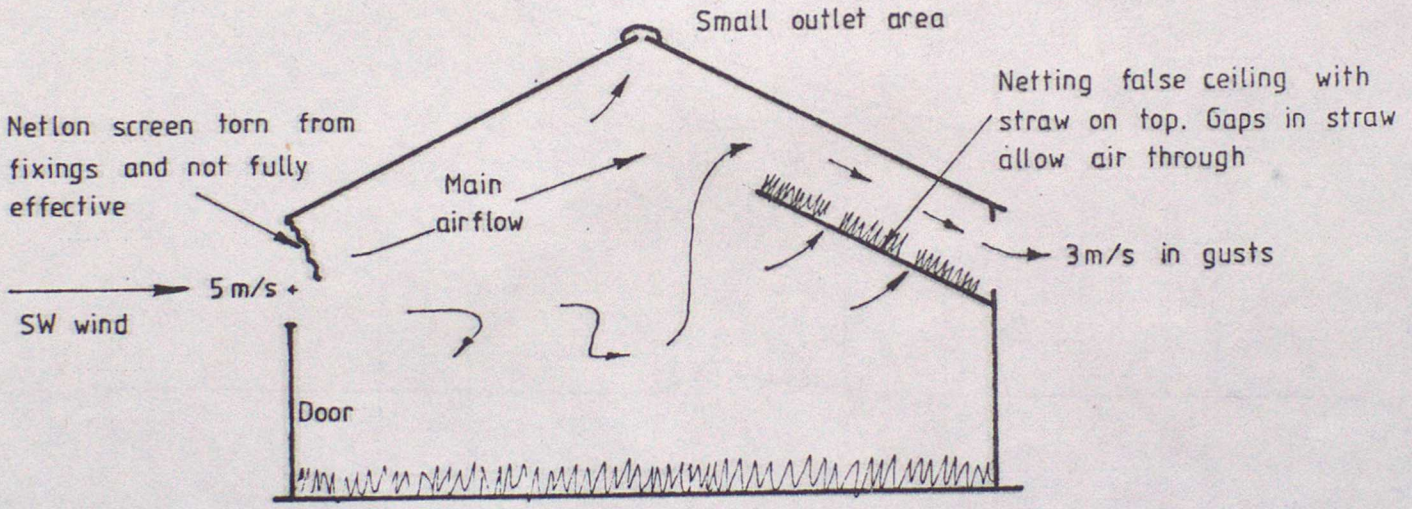
Farm 4 Dudgrove Farm, Fairford, Glos. Mr J. Peel

Visited on 5th January, 1982. J. Starr and D. Allott.

Siting Flat, gravel bearing ground. Some buildings over-exposed to South and West.

Weather on visit 1400 hrs. Heavy rain, strong wind SW gusting to 8 m/sec. By 1600 hours the front had passed with wind abated to max of 5 m/sec and slight rain.

The Buildings The calves and young cattle were in several buildings of pitched roof construction on East West axis. An exception was a large dutch barn open only to the East which provided sheltered accommodation but good ventilation due to its height. The young calves were in a small building divided into boxes. Older cattle were in straw yards about 10 m deep, open to the S beyond a feeding alley. One central dividing wall was not full height and the through airflow created draughty conditions.


Small outlet area
Netting false ceiling with straw on top. Gaps in straw allow air through
Netlon screen torn from fixings and not fully effective
Main airflow
3m/s in gusts
5 m/s +
SW wind
Door

Measurements taken
Calf house Outside up to 8 m/s. Inside at 1 m above floor gusting to 2 m/s; at straw level less than 0.2 m/s. Fast exit through rear eaves - 3 m/s. Noticeable airflow along axis of building above partition walls. Outside temp 10.2°c 90% RH inside temp 10.5°c at 88% RH. Yards after wind had dropped to 5 m/s gusts; yards still draughty with airspeed at 1 m height up to .5 m/s. Air changes rates were not measured as were obviously very rapid.

Assessments Excessive airflow through buildings in windy conditions giving draughty conditions for standing calves and standing or lying growers. Farmer recommended to use boarding and windbreak material to reduce wind penetration. Otherwise good housing.

Mites and Cattle. Winter 1981-82 Site visit

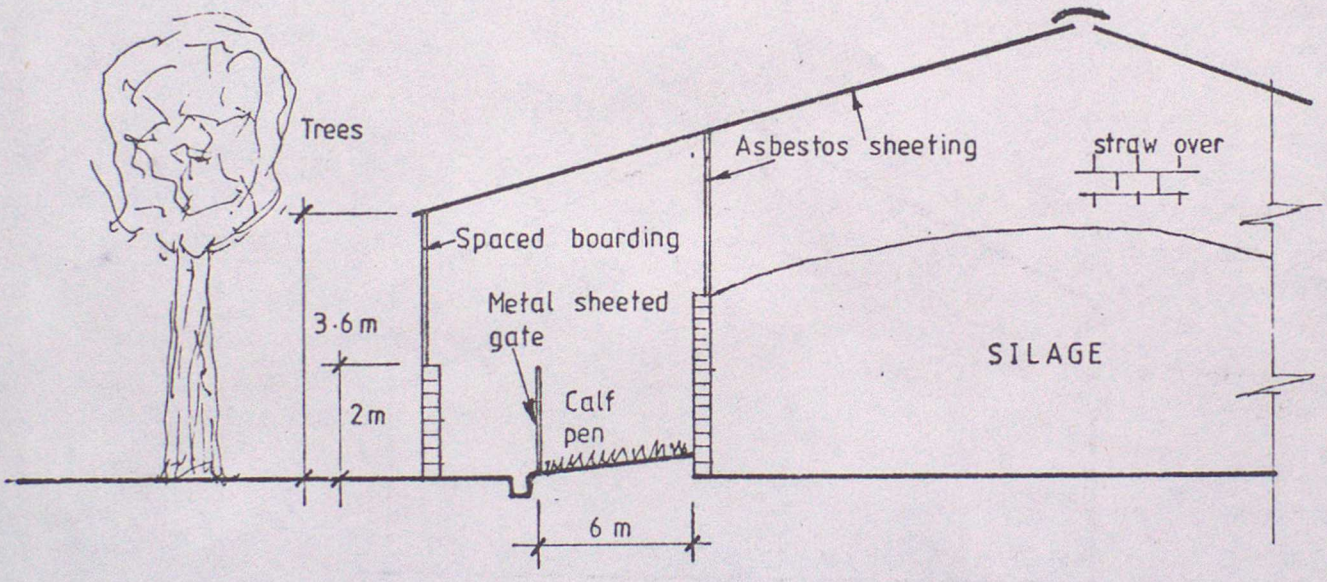
Farm 5 Henfold Farm, Beare Green, Dorking. Mr Montague.

Visited on 2nd March, 1982. J. Starr and D. Allott.

Siting Very well sheltered; tending to oversheltered to the West by tall trees. Lower ground to North.

Weather on visit Overcast. Light breeze S.W.

The Building One lean-to section of a large silage and straw barn was used for housing calves. The west wall is of blockwork with spaced boarding above. The division wall to the main barn is solid to the roof but some sheets are cut away to release air over the straw. There were no outlets in the roof, but a little ventilation at the ridge above the straw.



Measurements taken There were no calves in the building so it was not considered relevant to take any readings. There was no detectable air movement in the building.

Assessment Although generous in the provision of space at 15 sq ft per calf and a large volume the building is underventilated with no effective outlet. Recommended that fan extractor roof fittings be installed and that solid pen divisions and a section of Kennel lid would improve the shelter for calves. This would be a fairly airless site on still days so positive mechanical ventilation seems warranted.

Mites and Cattle. Winter 1981-82 Site visit

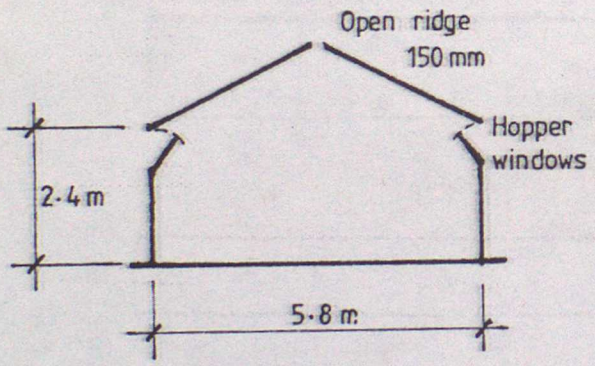
Farm 7 Upper Highfield Farm, Thursley, Godalming. Mr Abels

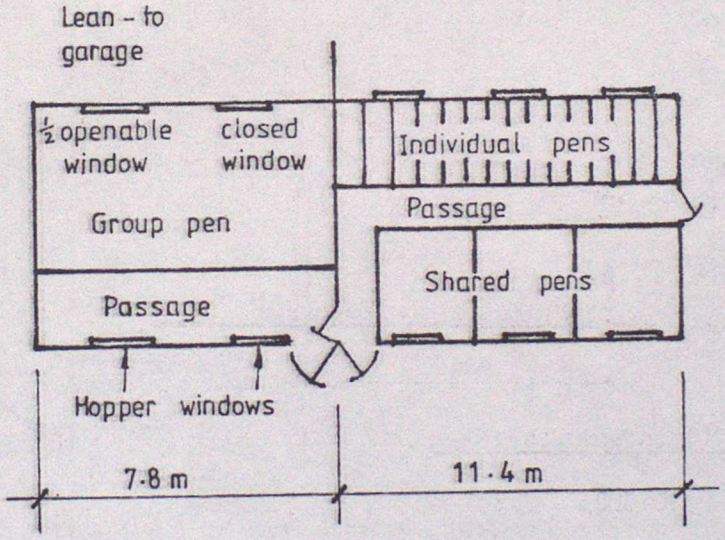
Visited on 2nd March, 1982
J. Starr and D. Allott

Siting On gently sloping ground facing North in hilly area. Calf housing sheltered by buildings and topography from most directions.

Weather on visit Overcast. breeze SW freshening. Rain forecast for end of the day.

Buildings An old narrow blockwork and asbestos roof building of 1920s smallholding style. Possibly built as cowshed. Garage built on as lean-to restricted airflow to part.





Measurements taken
Temperature/humidity. Outside 9.8°c. RH 54%
Inside, passage between calf pens 9.8°c RH 69%
Air speeds through openings 2-3 m/s on windward side, and 1-2 m/s on leeward side. Air detected leaving by ridge. Smoke and meters showed virtually still air at calf level. Both buildings less than ½ stocked. Air change rates measured by gas decay. In penned house, 10.4 changes/hr; in group house. 12.8 changes/hour.

Assessment
These seemed potentially good houses with adequate air change rates and no draughts at calf level. However, when fully stocked there might be inadequate ventilation on still days, and no kennel shelter if needed on windy days. The bedding was not very dry. Probably OK if managed well and diseases not mixed in from market calves.

Mites and Cattle. Winter 1981-82 Site visit

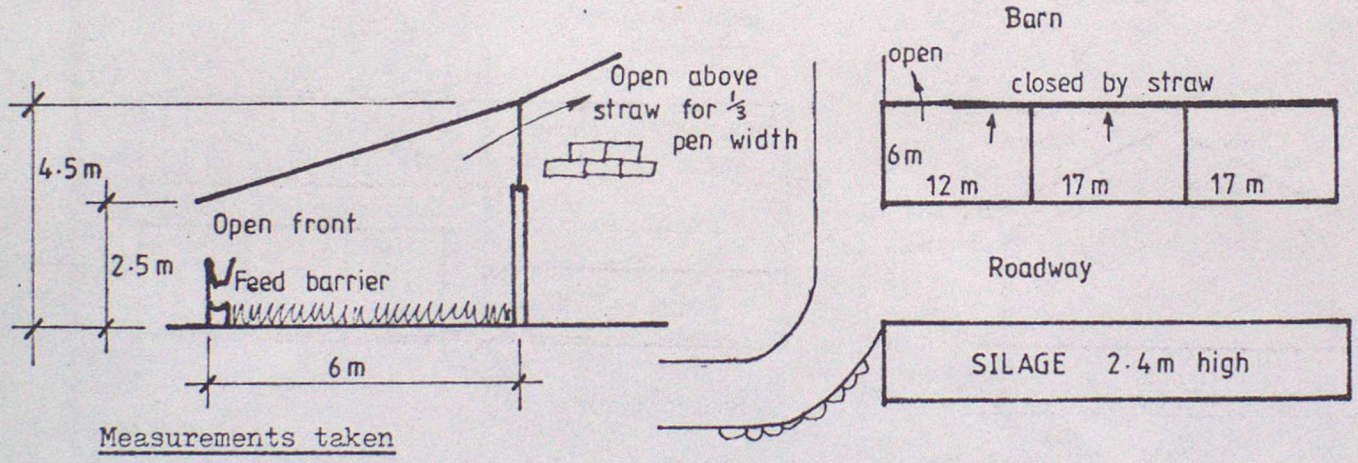
Farm 8 Draycott Moor Farm, Longworth. Mr Frost

Visited on 24 November, 1981. P. Roe and D. Allott

Siting Buildings on a low ridge (about 80 m) and over-exposed to weather from many directions. The "problem" pen has little protection from SW and NW winds. Nearby shelter hedge will help when fully grown. Other buildings and silage clamp protect from North and South.

Weather on visit Sunny, crisp. Fresh NW 3-4 m/s following cold front.

Building Lean-to on a large barn complex. Divided into 3 pens for loose-housed young stock.



Measurements taken

1330 GMT. Outside 5.9°c 51% RH
Inside 6.9°c 73% RH (1 m ht)
Air speeds. Outside, exposed, 3-4 m/sec @ 2 m
Sheltered by house, outside @ 1 m 0.5-1.5 m/sec
Inside end pen (youngest calves) near open back, 3-5 m/s
" " " At straw level 0.5-1.5 m/s
" " " " " " Sheltered back corner 0.1-0.5
" " " At front by feed trough. 0.4-1.4 m/s
Airchange rates measured by gas decay, but beyond range of reliability of instrument. At back of pen near outlet, 1 m above straw, about 95 air changes/hr. At sheltered part of pen, 1 m above straw, about 50/hr.

Assessment An exposed pen for the smallest stock made worse by bales removed from back wall. We replaced several and measured reduction in draughts. Farmer advised to improve wind protection. Otherwise, should be good, better if pen divided.